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Yoneda et al.

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[54] **WIRELESS LAN SYSTEM**

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[73] Assignee: **Fujitsu Limited,** Kanagawa, Japan

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[30] **Foreign Application Priority Data**

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[51] **Int. Cl.**[6] **H04Q 7/00**

[52] **U.S. Cl.** **340/825.02**; 340/825.04; 340/825.06; 395/200.02; 370/328; 370/329; 370/338

[58] **Field of Search** 340/825.02, 825.04, 340/825.03, 825.06, 825.07; 395/200.05, 200.02; 455/33.1, 33.2, 33.4; 370/310, 315, 316, 328, 329, 338

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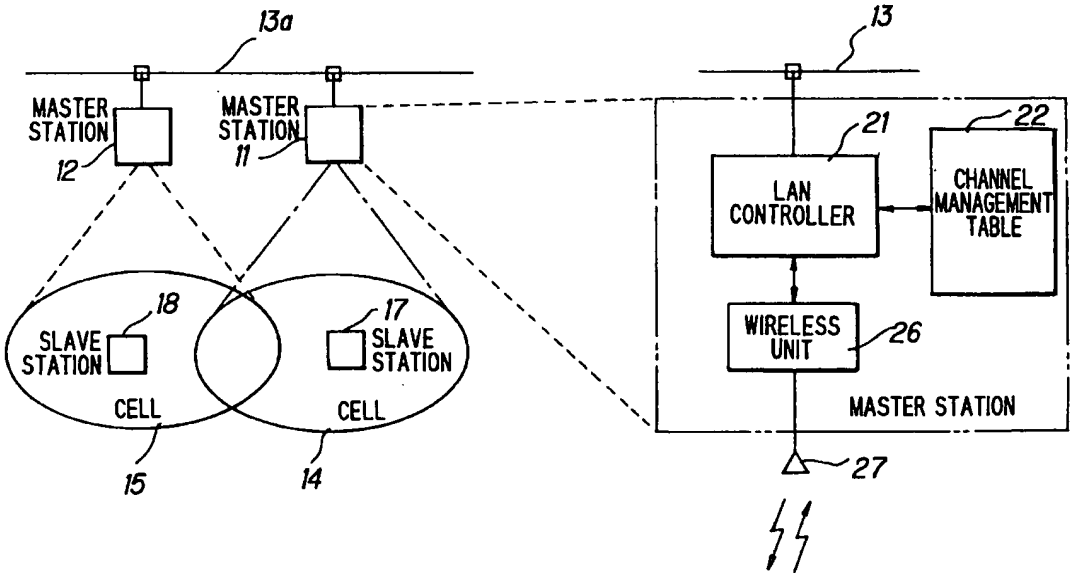
[57] **ABSTRACT**

In a wireless LAN system having two or more master stations each connected to a wired LAN and a plurality of slave stations each connected to a terminal for wirelessly sending and receiving signals to and from the master station via a prescribed channel, each master station is provided with a table for managing the state of channel use. The master station has a LAN controller which periodically notifies the other master station of the state of use of its own channel via a notification packet. Upon receiving a notification packet sent periodically from the other master station, the LAN controller stores the state of use of the channel of the other master station, of which it has been notified by the notification packet, in the channel management table. When it becomes necessary to allocate a channel to the slave station under its supervision, the LAN controller refers to the channel management table, selects a channel that is not being used by any other master station, allocates the selected channel to the slave station and communicates with the slave station. The LAN controller stores the state of use of its own channel in the table.

10 Claims, 10 Drawing Sheets



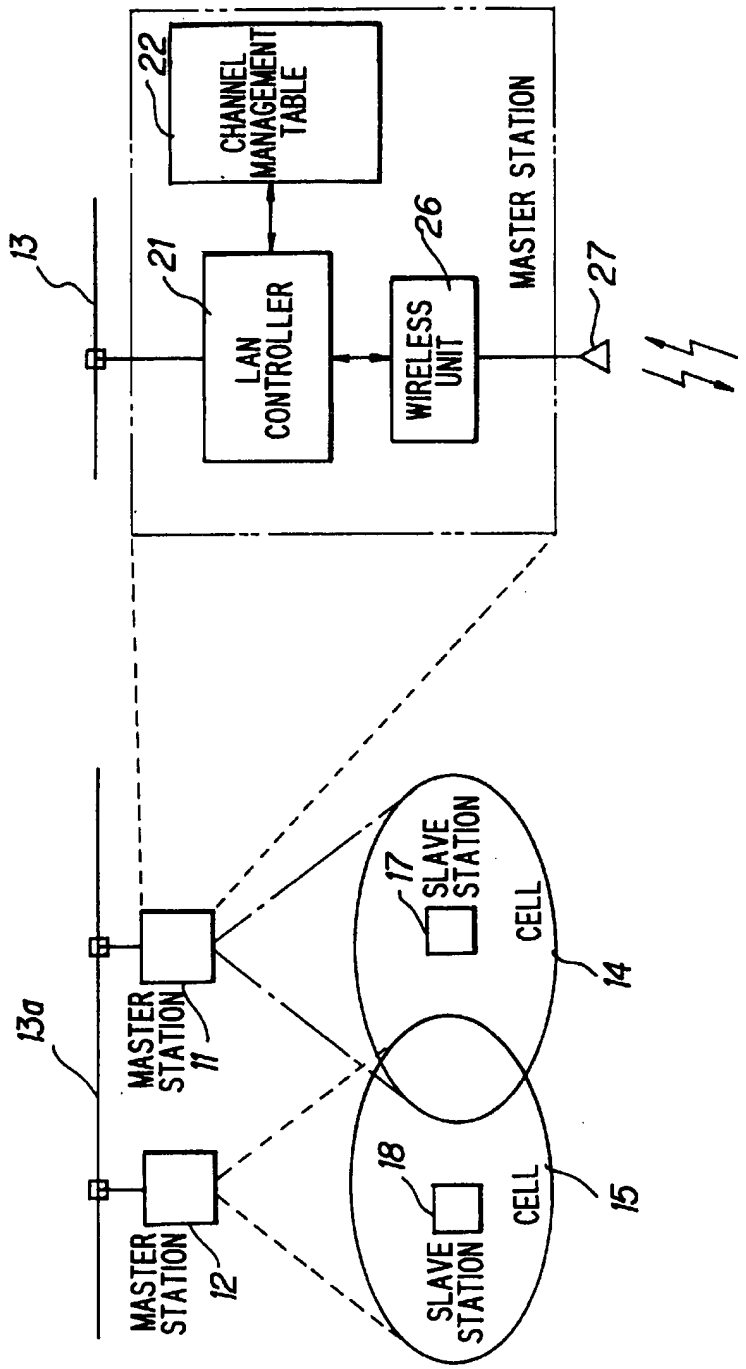

MASTER STATION
22
CHANNEL MANAGEMENT TABLE
21
LAN CONTROLLER
26
WIRELESS UNIT
27
13
13a
MASTER STATION 11
MASTER STATION 12
17
SLAVE STATION
CELL 14
18
SLAVE STATION
CELL 15

FIG. 1

FIG. 2A

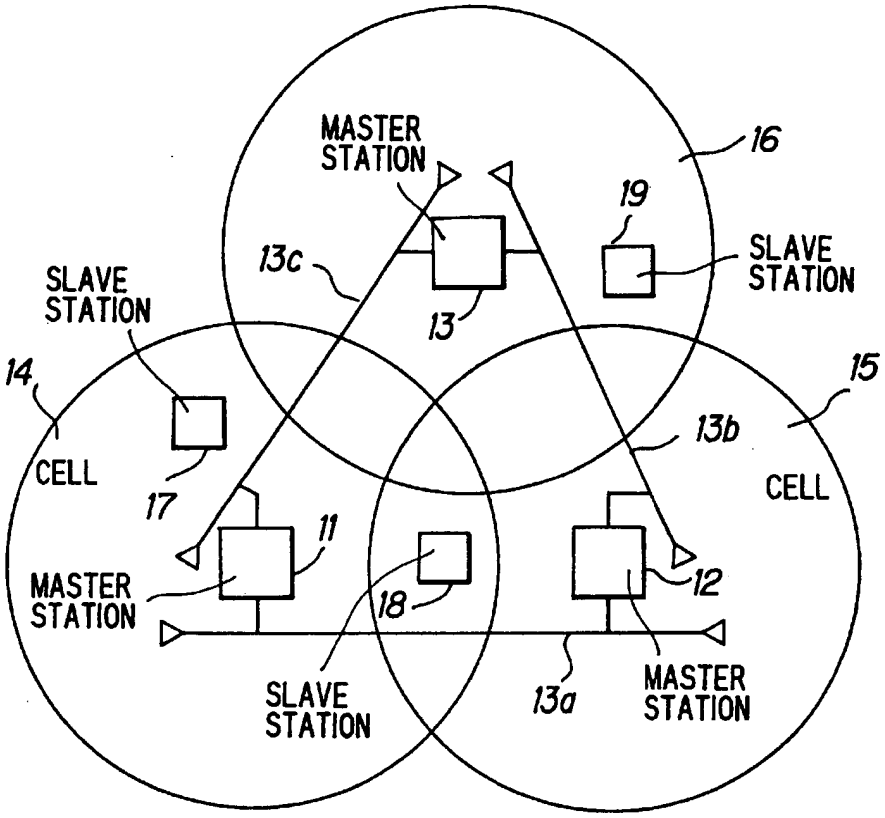

MASTER STATION
16
19
SLAVE STATION
13c
13
SLAVE STATION
14
15
13b
CELL
CELL
17
11
MASTER STATION
18
12
SLAVE STATION
13a
MASTER STATION

FIG. 2B

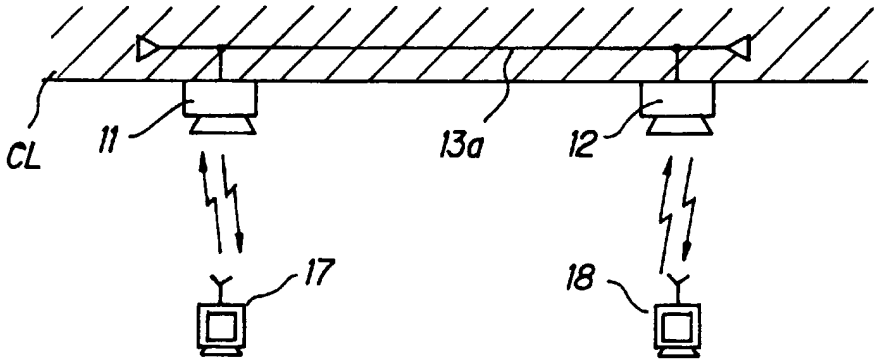

CL
11
13a
12
17
18

FIG. 3

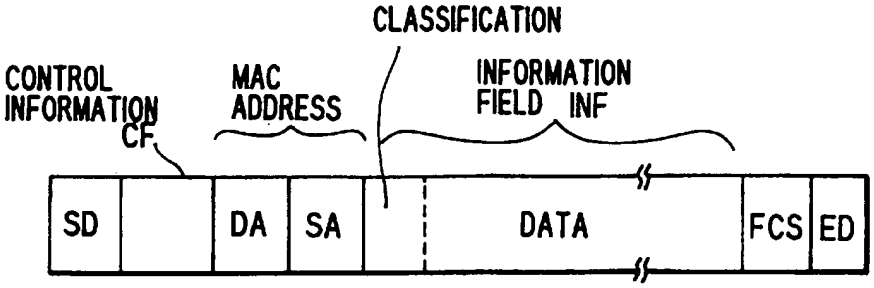

CLASSIFICATION
CONTROL INFORMATION CF
MAC ADDRESS
INFORMATION FIELD INF
SD
DA
SA
DATA
FCS
ED

FIG. 4

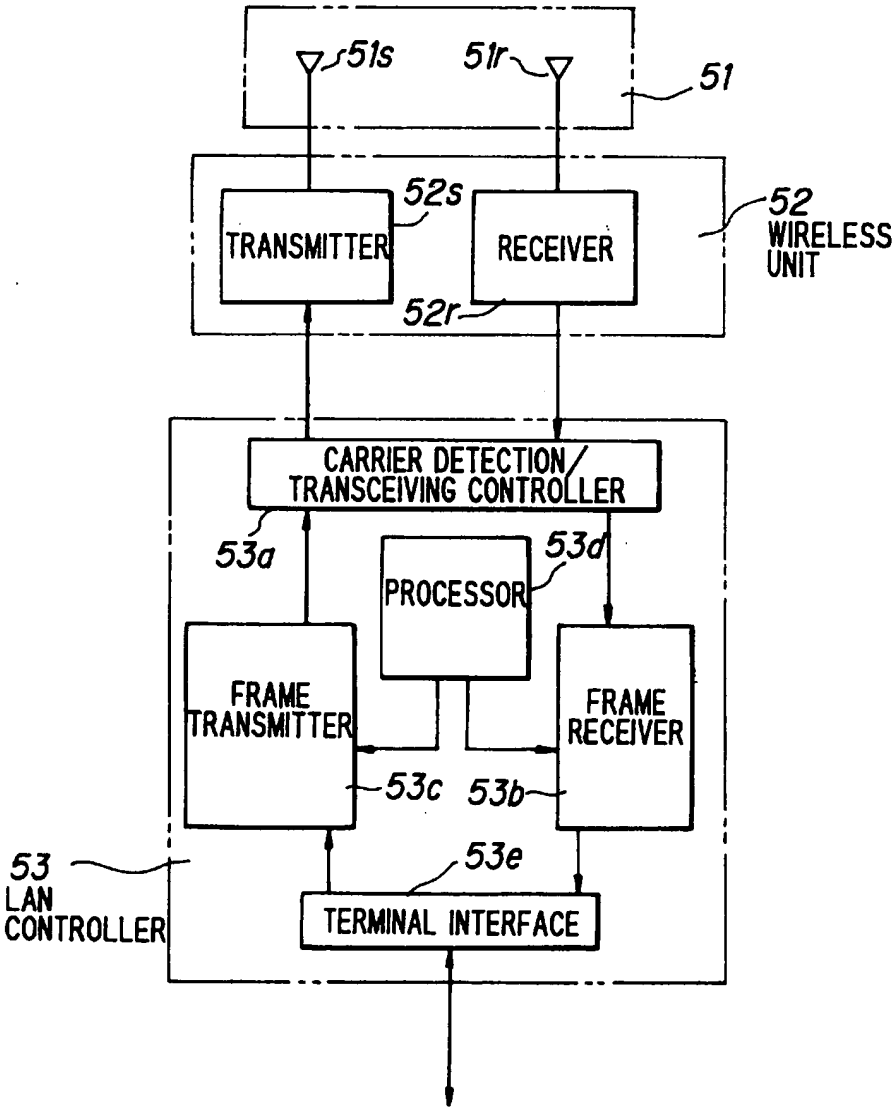

51s
51r
51
52s
TRANSMITTER
RECEIVER
52
WIRELESS UNIT
52r
CARRIER DETECTION/ TRANSCEIVING CONTROLLER
53a
53d
PROCESSOR
FRAME TRANSMITTER
FRAME RECEIVER
53c
53b
53e
53 LAN CONTROLLER
TERMINAL INTERFACE

FIG. 5

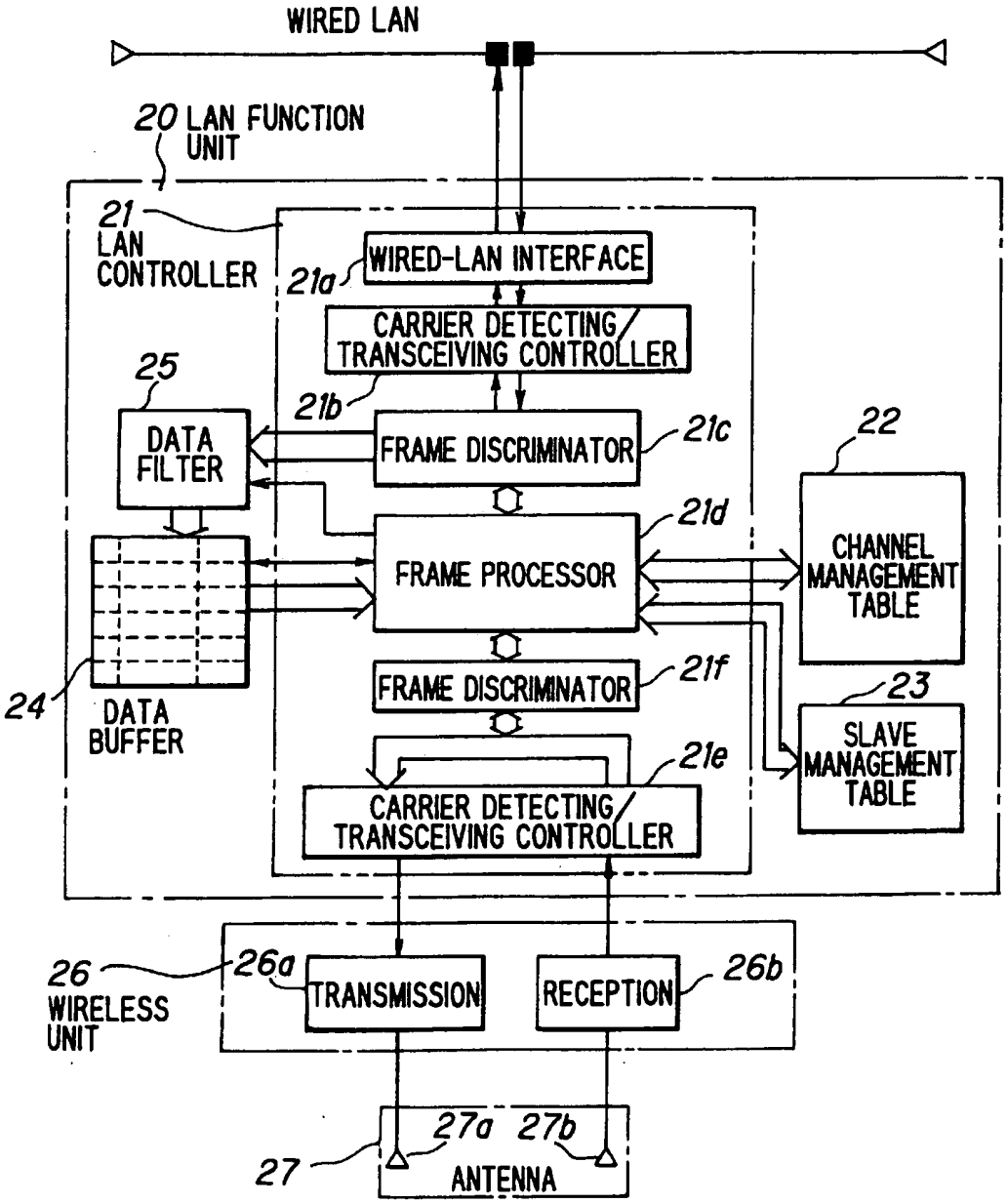

WIRED LAN
20 LAN FUNCTION UNIT
21 LAN CONTROLLER
21a WIRED-LAN INTERFACE
CARRIER DETECTING/ TRANSCEIVING CONTROLLER
25
21b
DATA FILTER
FRAME DISCRIMINATOR
21c
22
21d
FRAME PROCESSOR
CHANNEL MANAGEMENT TABLE
24
DATA BUFFER
FRAME DISCRIMINATOR
21f
23
SLAVE MANAGEMENT TABLE
21e
CARRIER DETECTING/ TRANSCEIVING CONTROLLER
26
WIRELESS UNIT
26a
TRANSMISSION
RECEPTION
26b
27
27a 27b
ANTENNA

FIG. 6

22a CHANNEL	22b INDICATION OF OWN CHANNEL IN USE	22c INDICATION OF CHANNEL IN USE BY OTHER STATION
FIRST CHANNEL		ON, ADDRESS OF ANOTHER MASTER STATION
SECOND CHANNEL	ON	
⋮	⋮	⋮
n-th CHANNEL		

FIG. 7

23a SLAVE STATION ADDRESS	23b ALLOCATED CHANNEL

FIG. 8

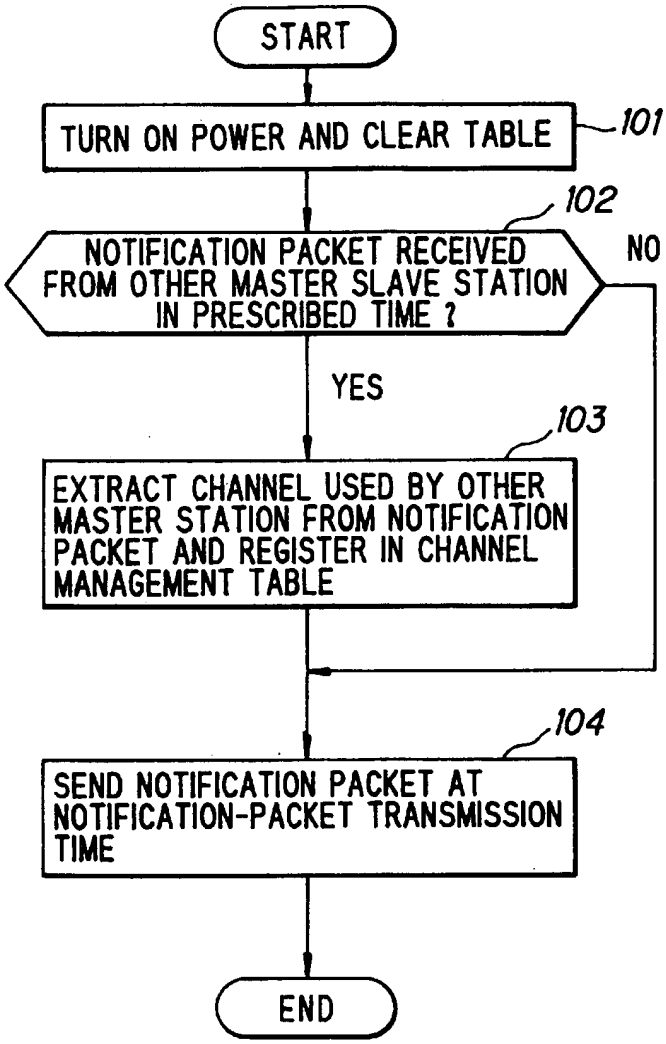

START
TURN ON POWER AND CLEAR TABLE
101
102
NOTIFICATION PACKET RECEIVED FROM OTHER MASTER SLAVE STATION IN PRESCRIBED TIME ?
NO
YES
103
EXTRACT CHANNEL USED BY OTHER MASTER STATION FROM NOTIFICATION PACKET AND REGISTER IN CHANNEL MANAGEMENT TABLE
104
SEND NOTIFICATION PACKET AT NOTIFICATION-PACKET TRANSMISSION TIME
END

FIG. 9

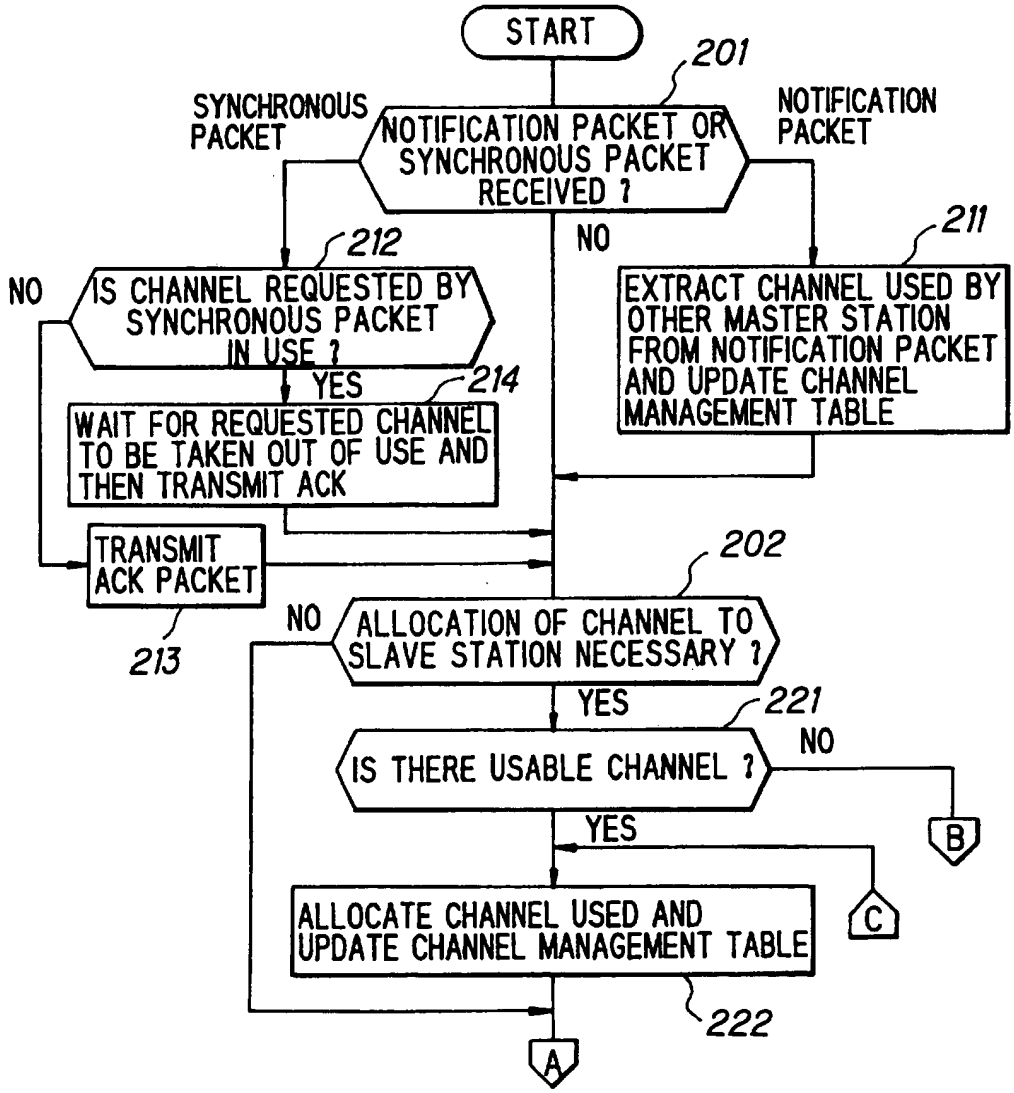

START
201
NOTIFICATION PACKET OR SYNCHRONOUS PACKET RECEIVED ?
SYNCHRONOUS PACKET
NOTIFICATION PACKET
NO
212
IS CHANNEL REQUESTED BY SYNCHRONOUS PACKET IN USE ?
NO
YES
214
WAIT FOR REQUESTED CHANNEL TO BE TAKEN OUT OF USE AND THEN TRANSMIT ACK
211
EXTRACT CHANNEL USED BY OTHER MASTER STATION FROM NOTIFICATION PACKET AND UPDATE CHANNEL MANAGEMENT TABLE
TRANSMIT ACK PACKET
213
202
NO
ALLOCATION OF CHANNEL TO SLAVE STATION NECESSARY ?
YES
221
IS THERE USABLE CHANNEL ?
NO
B
YES
C
ALLOCATE CHANNEL USED AND UPDATE CHANNEL MANAGEMENT TABLE
222
A

FIG. 10

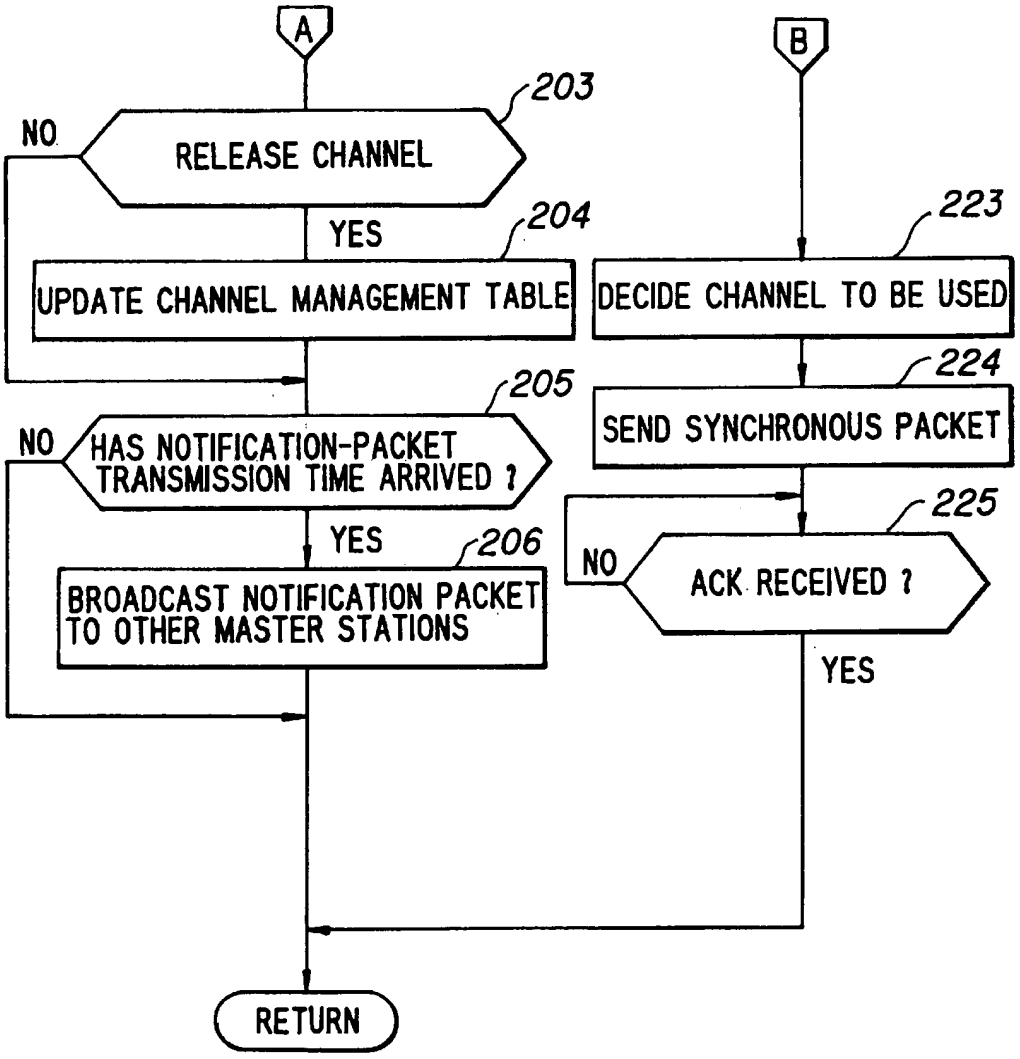

A
B
203
NO
RELEASE CHANNEL
YES
204
UPDATE CHANNEL MANAGEMENT TABLE
205
NO
HAS NOTIFICATION-PACKET TRANSMISSION TIME ARRIVED ?
YES
206
BROADCAST NOTIFICATION PACKET TO OTHER MASTER STATIONS
223
DECIDE CHANNEL TO BE USED
224
SEND SYNCHRONOUS PACKET
225
NO
ACK RECEIVED ?
YES
RETURN

FIG. 11

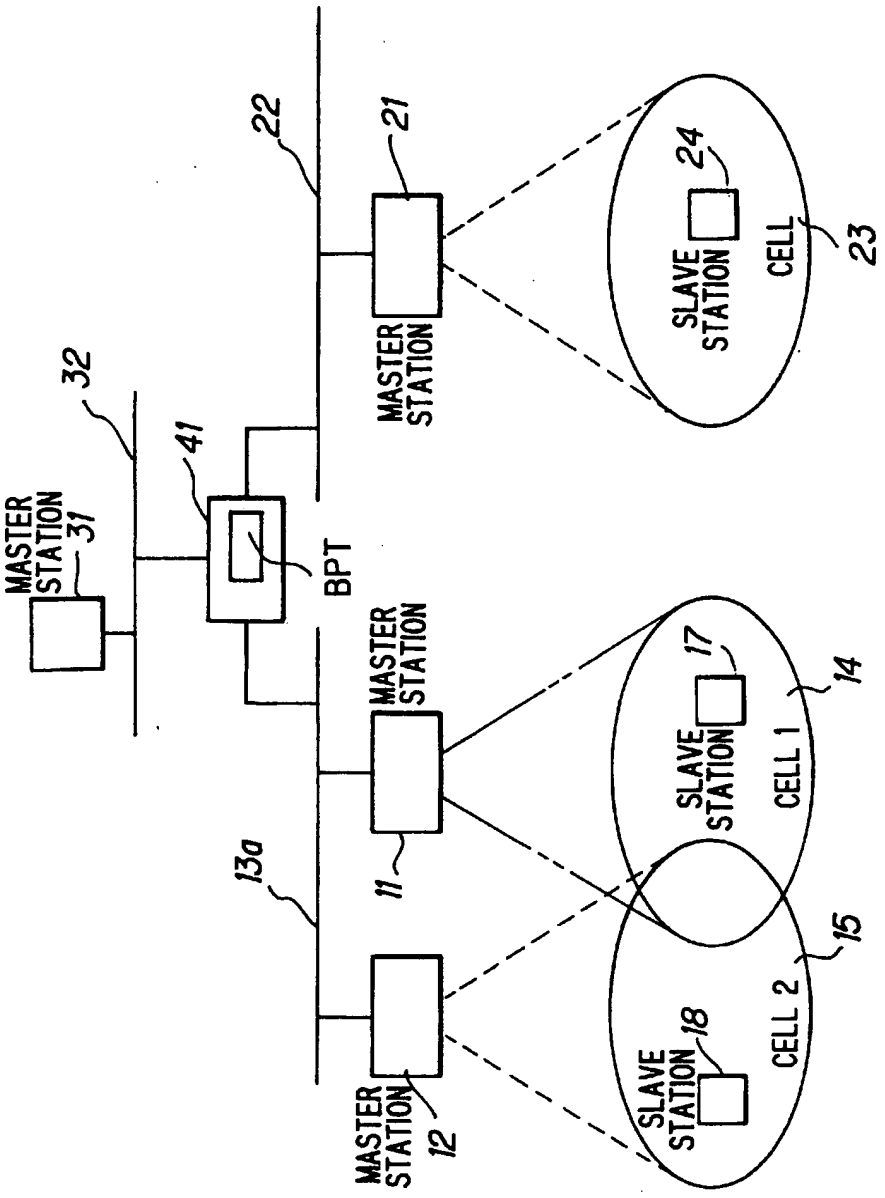

MASTER STATION 31
32
41
BPT
22
MASTER STATION 21
MASTER STATION 11
MASTER STATION 12
13a
SLAVE STATION 24
CELL 23
SLAVE STATION 17
CELL 1 14
SLAVE STATION 18
CELL 2 15

FIG. 12

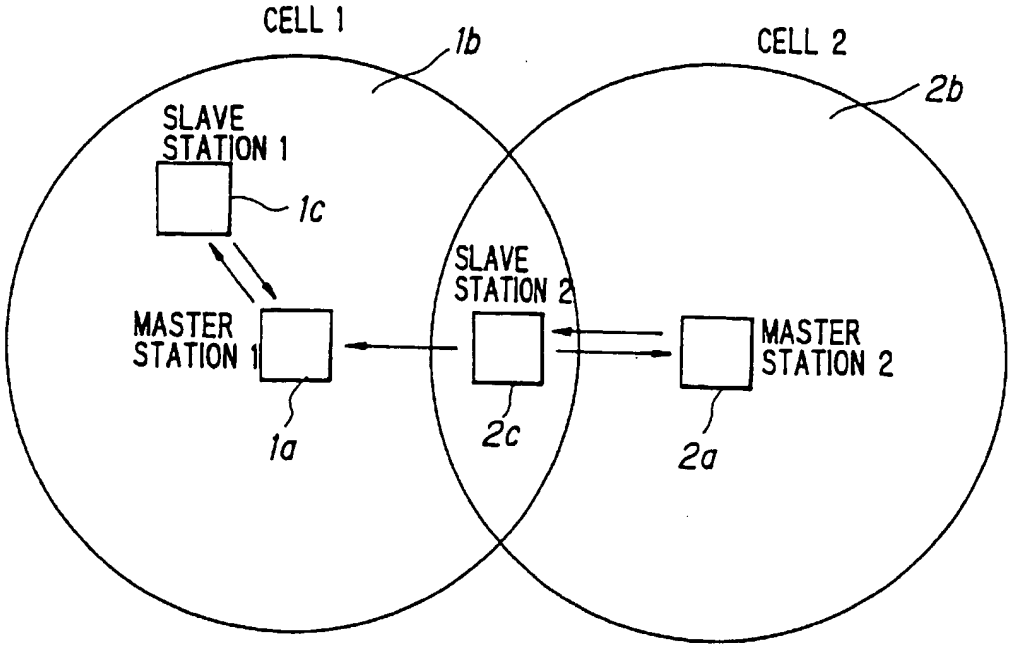
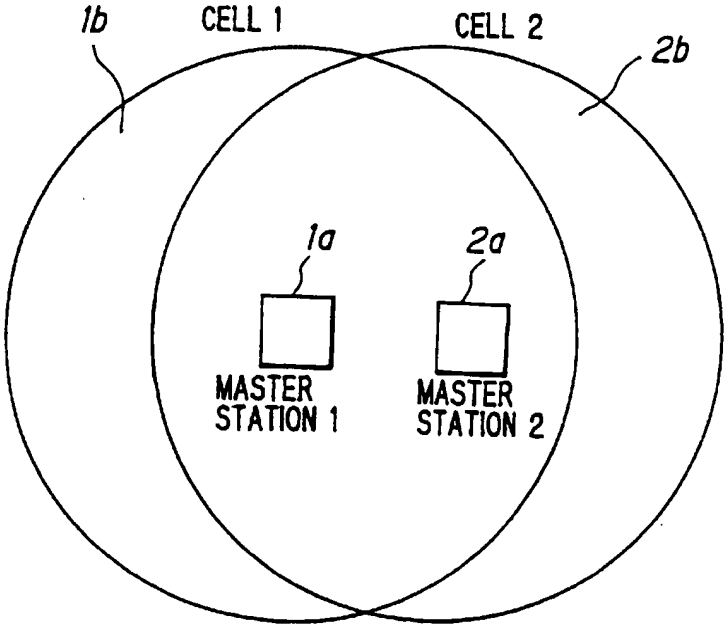


FIG. 13 PRIOR ART



WIRELESS LAN SYSTEM

BACKGROUND OF THE INVENTION

This invention relates to a wireless LAN system and, more particularly, to a wireless LAN system having two or more master stations each connected to a wired LAN and slave stations connected to terminals for wirelessly sending and receiving signals to and from the master stations.

Use of LANs (Large Area Networks) is becoming increasingly popular at a rapid rate. A LAN allows data communication among a plurality of terminals, such as personal computers or work stations, installed at scattered locations at the same site, or between the terminals and a host computer, and allows programs and data files to be shared. Such a LAN basically is a wired LAN which connects each terminal or the host computer to basic cables (LAN cables) in the network.

When the number of terminals connected to the network in a wired LAN increases, the wiring laid within the room becomes very complicated. In a case where a terminal is portable, the advantage of portability is lost when the terminal is physically connected to the basic cable.

A wireless LAN has been proposed and is being put into practical use for the purpose of solving the aforementioned problems which arise with a wired LAN. In a wireless LAN, a backbone LAN is constructed by installing the basic cable in a ceiling or the like and installing a plurality of master stations each having a wireless device capable of transmitting signals to and receiving signals from the basic cable. Slave stations (each incorporating radio equipment) connected to terminals communicate with one another wirelessly via the backbone LAN. In accordance with this wireless LAN, it is unnecessary to connect the slave terminals to the basic cable. This solves the wiring problems of the wired LAN and does not detract from the original features of a portable terminal.

FIG. **12** is a diagram for describing master stations in a wireless LAN system and areas (cells) in which the master stations can communicate with slave stations. FIGS. **1***a*, **2***a* denote master stations, **1***b*, **2***b* areas (cells), conforming to the master stations, in which signals can be sent and received, and **1***c*, **2***c* slave stations. Each master station is so adapted as to be capable of sending and receiving frames (packets) via a backbone LAN, which is not shown. Multiple cells are arranged in such a manner that the cells of the master stations **1***a*, **2***a* partially overlap each other. The reason for constructing multiple cells in this manner is to arrange it so that communication via the LAN will not be interrupted even when a slave station is moved between cells while being carried or to eliminate blank areas in which LAN communication cannot be performed.

In such a multiple-cell environment, a problem which arises is that a packet received from the slave station **2***c*, which is present in an area in which neighboring cells overlap, is received by a plurality of master stations **1***a*, **2***a*, each of which sends the received frame to the backbone LAN at the same time, thereby causing frame collision and inviting loss of frames. Though control for re-sending frames upon changing the transmission timing is performed when collision occurs, a problem which arises in such case is that identical frames are sent to the receiving party in redundant fashion.

In order to avoid the interference problem which arises when adjacent cells overlap, a first method is to set beforehand the channel used by each master station so as to be different from the channels of adjacent stations. For example, a channel is made different from the channels of adjacent cells by changing the frequency, the frequency hopping sequence (Frequency Hopping Sequence Spread Spectrum, or FHSS), the diffusion code (Direct Sequence Spread Spectrum, or DSSS), the time slot, etc. A second method is one in which the channels used are not set in advance.

A problem encountered with the first method is that the channels used must be set before the system is operated, as a result of which system design takes time and there is a decline in the number of channels that can be used.

A problem which arises with the second method is hidden terminals. More specifically, if the slave station **1***c* is communicating upon obtaining transmission permission from the master station **1***a* on a certain channel CHi, there are cases where the slave station **2***c* present in the area where the cells **1***b* and **2***b* overlap performs communication upon being allocated with a channel, which is identical with channel CHi, by the master station **2***a*. In such case the slave station **2***c* transmits a packet to the master station **2***a* as well. In the master station **1***a*, therefore, the packets from the slave stations **1***c*, **2***c* collide. This is the so-called "hidden terminal" problem.

Further, in a multiple-cell environment in which the master stations **1***a*, **2***a* reside in an area in which the cells **1***b* and **2***b* overlap, as shown in FIG. **13**, the master stations send and receive information to and from each other by radio waves (wirelessly) and not by a wired LAN. That is, though the backbone LAN is constructed by a wireless LAN rather than a wired LAN, complicated processing is required in order to obtain the information of another master station from radio waves. This places a large burden upon the master stations.

SUMMARY OF THE INVENTION

A first object of the present invention is to arrange it so that the problem of hidden terminals in a wireless LAN system will not occur.

A second object of the present invention is to provide a wireless LAN system in which master stations are connected by a wired LAN and inform one another of channels used, whereby each master station ascertains a channel not being used by other master stations, selects the channel not being used and allocates it to a slave station to communicate with the slave station.

A third object of the present invention is to provide a wireless LAN system in which, when it becomes necessary for a master station to allocate a channel to a slave station and an idle channel does not exist, the master station interrogates other master stations with regard to the state of use of a prescribed channel and, if the channel is not being used, makes use of this channel, thereby performing channel allocation more efficiently.

A fourth object of the present invention is to provide a wireless LAN system in which a packet (a notification packet) notifying of a channel used and a packet (synchronous packet) requesting a channel are blocked at a network repeater such as a bridge, thereby making it possible to prevent an increase in the traffic of other wired LANs.

The first through third objects of the invention of the present invention are attained by providing a wireless LAN system having two or more master stations each connected to a wired LAN and a plurality of slave stations each connected to a terminal for wirelessly sending and receiving signals to and from the master stations via a prescribed

channel, wherein each master station comprises a table for managing state of use of channels, means for transmitting state of use of its own channel to other master stations periodically in the form of a notification packet, means for storing state of use of channel of another master station in the table when a notification packet has been received from the other master station, means for selecting a channel not being used by any other master station upon referring to the table when communication is to be performed with a slave station under its supervision, and means for communicating with the slave station via the channel selected.

Further, according to the present invention, the wireless LAN system for attaining the fourth object includes a network repeater connected to a plurality of wired LANs for relaying packets sent and received between wired LANs, wherein each master station transmits the notification packet or synchronous packet in the form of a short packet no larger than a minimum packet length stipulated for the wired LANs or changes a CRC operational code to a predetermined CRC operational code and transmits the notification packet or synchronous packet, the network repeater detects the short packet or the packet of a CRC error and then discards the packet, and another master station connected to the same wired LAN as the above-mentioned master station accepts and processes the short packet or the packet having the predetermined CRC operational code without discarding the packet.

Other features and advantages of the present invention will be apparent from the following description taken in conjunction with the accompanying drawings, in which like reference characters designate the same or similar parts throughout the figures thereof.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a diagram for describing an overview of the present invention;

FIGS. **2**A and **2**B are diagrams showing the configuration of a wireless LAN system according to the present invention;

FIG. **3** is a diagram showing the composition of a frame;

FIG. **4** is a block diagram showing the construction a slave station;

FIG. **5** is a block diagram showing the construction a master station;

FIG. **6** is a diagram showing the composition of table for managing channels used;

FIG. **7** is a diagram showing the composition of a slave-station management address table;

FIG. **8** is a flowchart of processing executed when a power supply is turned on;

FIG. **9** is a flowchart of processing for channel allocation under ordinary conditions;

FIG. **10** is a flowchart of processing for channel allocation under ordinary conditions;

FIG. **11** is a diagram showing another configuration of a wireless LAN system;

FIG. **12** is a diagram for describing the relationship between master stations and cells in a wireless LAN system; and

FIG. **13** is a diagram for describing the problems of the prior art.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

(A) Overview of the invention

FIG. **1** is a diagram for describing an overview of a wireless LAN system according to the present invention.

As shown in FIG. **1**, the wireless LAN system includes master stations **11**, **12** for sending/receiving frames (packets) to/from slave stations, a wired LAN **13***a* serving as a backbone LAN to which the master stations are connected, cells **14**, **15** conforming to the master stations **11**, **12**, and slave stations **17**, **18**.

Each master station has a LAN controller **21**, a channel management table **22** for managing the state of use of channels, a transceiver (radio equipment) **26** and an antenna **27**.

Thus, the master stations **11**, **12** connected to the wired LAN **13***a* are each provided with the channel management table **22** for managing the state of use of channels. The LAN controller **21** periodically notifies the other master station of the state of use of its own channel via a notification packet. Upon receiving a notification packet sent periodically from the other master station, the LAN controller **21** stores the state of use of the channel of the other master station, of which it has been notified by the notification packet, in the table **22**. When it becomes necessary to allocate a channel to the slave station **17** under its supervision, the LAN controller **21** refers to the table **22**, selects a channel that is not being used by any other master station, allocates the selected channel to the slave station and communicates with the slave station. In this case, the LAN controller **21** stores the state of use of its own channel in the table **22**.

If this arrangement is adopted, the problem of hidden terminals does not arise because the same channel is not allocated to slave stations redundantly in two neighboring cells.

In a case where all channels are in use and an idle channel for allocation to a slave station does not exist, a master station sends the other master station a synchronous packet containing identification data of a channel desired to be used. If it is ascertained by a packet in response to the synchronous packet that the other station is not using the above-mentioned channel, the master station immediately selects this channel and communicates with the slave station. Thus, a channel desired for use can be used immediately if it is not being used by another master station. If the channel is being used, the master station can use the channel at the end of its use. This makes channel allocation more efficient.

In this case, the master station that has received the synchronous packet refers to the table **22** to determine whether the channel specified by the identification data contained in the synchronous packet is being used by the master station itself. If this channel is not in use, then the master station transmits an ACK packet as the response packet. If the channel is being used, the master station transmits the ACK packet after use of the channel ends. Further, the master station that has received the synchronous packet is also capable of transmitting a notification packet as the response to the synchronous packet.

When the wireless LAN system becomes extensive, a plurality of wired LANs are provided and the wired LANs are interconnected by a network repeater such as a bridge. If the wired LANs differ in such a system, the problem of hidden terminals will not arise even if the same channel is allocated redundantly. Here the master station transmits the notification packet or synchronous packet in the form of a short packet of less than the minimum packet length stipu-

lated for the wired LANs. The network repeater detects and discards the short packet but another master station connected to the same wired LAN as the above-mentioned master station accepts the short packet and executes the above-mentioned channel allocation processing, processing for updating the used-channel management table and processing for transmitting various packets, etc. If this arrangement is adopted, a notification packet or synchronous packet will not be sent to another wired LAN and, hence, there will be no increase in the traffic of the other wired LAN. Moreover, since the packet has the form of the short packet, the traffic carried by the wired LAN to which the master station can be suppressed.

Further, instead of using the short packet, a master station may change the CRC operational code of the notification packet and/or synchronous packet to a predetermined code and transmit the predetermined code. The network repeater detects the packet for which the CRC operational code has been changed (detection by CRC check error) and discards the packet. The other master station accepts the packet having the predetermined CRC operational code, regardless of the CRC check error, and executes the above-mentioned processing. Thus, since the notification packet or synchronous packet will not be sent to the other wired LANs, traffic on the other wired LANs is not increased.

(B) First Embodiment

(a) System configuration

FIG. **2**A is a diagram showing the configuration of a wireless LAN system according to the present invention. As shown in FIG. **2**A, the wireless LAN system includes master stations **11**, **12**, **13** for sending/receiving frames (packets) to/from slave stations, wired LANs **13***a*~**13***c* serving as backbone LANs to which the master stations are connected, cells, **14**, **15**, **16** conforming to the master stations **11**, **12**, **13**, respectively, and slave stations **17**, **18**, **19**. As shown in FIG. **2**B, the wired LANs **13***a*~**13***c* are laid on a ceiling CL and have the master stations **11**~**13** connected to them at appropriate locations.

FIG. **3** is a diagram showing the basic composition of a frame (packet) used in a wireless LAN. Here (1) a control field CF, (2) a layer-**2** MAC address (constituted by a destination address DA and a sending address SA), (3) an information field INF and (4) a frame checking sequence FCS based upon a CRC (cyclic redundancy check) are placed between a start delimiter SD and an end delimiter ED. The information field INF contains the frame classification (notification packet, synchronous packet, etc.). In the case of an Ethernet network, the minimum byte length of a packet is 64 bytes.

(b) Construction of slave station

FIG. **4** is a block diagram showing the construction a slave station. The slave station includes an antenna **51** having a receiving antenna **51***r* and a transmitting antenna **51***s*, though a single antenna may be used as these two antennae. The antenna **51***r*, **51***s* are constructed to have directivity and are adjusted so as to point toward the antenna of the master station of the cell to which the slave station belongs. Numeral **52** denotes a wireless unit having a receiver **52***r* and a transmitter **52***s*. The slave station further includes a LAN controller **53** having a carrier detecting/transceiving controller **53***a* for detecting a carrier and controlling sending/receiving, a frame receiver **53***b*, a frame transmitter **53***c*, a frame processor **53***d* and a terminal interface **53***e*.

(c) Construction of master station

FIG. **5** is a block diagram showing the construction of a master station. The master station includes a LAN functional unit having the LAN controller **21**, the channel management table **22** for managing the state of use of channels, a slave management table **23** for storing the addresses of slave stations under the supervision of the master station as well as channels that have been allocated to these slave stations, a data buffer **24** for temporarily storing data addressed to the slave stations, a data filter **25** for accepting the data addressed to the slave stations under supervision and storing the data in the data buffer **24**, a transceiver (radio equipment) having a transmitter **26***a* and a receiver **26***b*, and an antenna **27**. Though a transmitting antenna **27***a* and a receiving antenna **27***b* are illustrated as the antenna **27**, a single antenna can be used as both of these antennae.

As shown in FIG. **6**, the channel management table **22** has a channel identification code column **22***a*, a column **22***b* indicating that a channel is being used by the master station itself, and a column **22***c* indicating that a channel is being used by another master station. It should be noted that the column **22***c* includes not only an indication of whether a channel is or is not in use but also the address of the other master station using a channel if the channel is in use.

As shown in FIG. **7**, the slave management table **23** is so arranged as to store addresses **23***a* of slave stations under supervision as well as channels **23***b* allocated to these slave stations.

As shown in FIG. **5**, the LAN controller **21** includes a wired-LAN interface **21***a* for interfacing the wired LAN, a carrier detection/transception controller **21***b* for detecting a carrier on the wired LAN and controlling the sending/receiving of frames (packets) with respect to the wired LAN, a frame discriminator **21***c*, a frame processor **21***d*, a carrier detection/transception controller **21***e* for detecting a carrier from a slave station and controlling the sending/receiving of frames with respect to the slave station, and a frame discriminator **21***f*.

The frame processor **21***d* has the following functions:

(1) The frame processor **21***d* periodically creates a notification packet for giving notification of the state of use of its own channel and broadcasts the notification packet to other master stations via the wired LANs.

(2) If a notification packet has been received, the frame processor **21***d* registers the state of channel use of another master station, of which it has been notified by the notification packet, in the channel management table **22**.

(3) When it becomes necessary to allocate a channel to a slave station under supervision, the frame processor **21***d* refers to the channel management table **22**, obtains a channel not being used by any other master station and allocates this channel to the slave station.

(4) When a channel has been allocated to a slave station or a channel that has been allocated to a slave station is finished being used, the frame processor **21***d* rewrites the indication that its own channel is in use to "IN USE" or "NOT IN USE" in the channel management table **22**.

(5) In a case where an idle channel to be allocated to a slave station under supervision does not exist, the frame processor **21***d* decides a channel desired to be used, creates a synchronous frame in which the identification code of this channel is included in the information field INF, and introduces the frame into the wired LAN by multicasting.

(6) In a case where a synchronous frame has been received, the frame processor **21***d* determines whether the channel designated by the synchronous frame is

being used or not. If the channel is not being used, then the frame processor **21***d* immediately sends an ACK frame to the master station that transmitted the synchronous frame. On the other hand, if the channel designated by the synchronous frame is being used, the frame processor **21***d* transmits the ACK frame after use of the channel is finished. If ACK frames are received from all master stations, the frame processor **21***d* of the master station that transmitted the synchronous frame allocates the above-mentioned channel to the slave station.

It should be noted that an arrangement can be adopted in which the master station refers to the channel management table **22**, obtains a master station for which a channel that has been allocated to a slave station is being used, sends the synchronous frame solely to this master station and, when the ACK frame is received from this master station, allocates the channel to the slave station.

(d) Channel allocation control

(d-1) Control at introduction of power

FIG. **8** is a flowchart of processing at introduction of power to a master station.

When power is introduced to a prescribed master station, say the master station **11**, the frame processor **21***d* of the master station **11** clears the channel management table **22** (step **101**). Next, the frame processor **21***d* checks to determine whether the notification packet has been received from the other slave stations **12**, **13** via the wired LAN within the transmission period of the notification packet, e.g., several seconds (step **102**).

If introduction of power to the master station **11** occurs earlier than introduction of power to the other master stations, the notification packet is not received. However, if there is another master station to which power is introduced earlier than the master station **11**, the notification packet is received from this other master station. As a result, the channel used by the other master station is extracted from the notification packet and written in the channel management table **22** (step **103**).

Next, at the transmission timing of the notification packet, the master station notifies other master stations of the state of its own channel use via the wired LAN (step **104**) and then executes ordinary channel allocation processing, described later.

(d-2) Channel allocation control under ordinary ordinary conditions

FIGS. **9** and **10** are flowcharts of processing for channel allocation under ordinary conditions.

Monitoring is performed to determine whether the notification packet or synchronous packet has been received from another master station via the wired LAN (step **201**). If the packet has not been received, it is determined whether it is necessary to allocate a channel to a slave station (step **202**). A case in which it is necessary to allocate a channel to a slave station is (1) a case in which a channel allocation is requested of the master station by channel control in order that the slave station under supervision may access the LAN, or (2) a case in which the master station receives a packet, which is addressed to a slave station under supervision, via the wired LAN and desires to transmit the packet to the slave station.

If it is unnecessary to allocate a channel to a slave station, then a check is made to determine whether use of a channel allocated to any slave station under supervision has ended as by the end of transmission of a packet. If use of a packet allocated to any slave station has ended, this channel is freed for use (step **203**). After release of the channel, "NOT IN USE" is entered into the channel management table **22** to correspond to the released channel in column **22***b*, which indicates that the channel is being used by the master station itself, and updates the content of the slave management address table **23***b* (step **204**).

Next, or if it is unnecessary to release the channel at step **203**, the transmission timing of the notification packet is checked (step **205**). If it is time to transmit a notification packet, the packet is created in order to notify of the state of use of the master station's own channel and the notification packet is transmitted to the other master stations by broadcast via the wired LANs (step **206**). Thereafter, or in a case where the time for transmission of the notification packet has not arrived, the program returns to the beginning and the foregoing processing is repeated.

If a notification packet is received from another master station at step **201**, the channel used by the other master station is extracted from the notification packet, the channel is written in the channel management table **22** in the column **22***c* indicating that the channel is being used by another master station (step **211**) and then processing from step **202** onward is executed. In this case, "IN USE" is entered into the column **22***c* to correspond to the channel being used and so is the address of the master station using the channel.

If the synchronous packet is received at step **201**, reference is had to the channel management table **22** to determine whether the channel being requested by the synchronous packet is currently being used (step **212**). If the table **22** indicates "NOT IN USE", then the ACK packet is immediately transmitted to the sender of the synchronous packet (step **213**), after which the processing from step **202** onward is executed. If the channel is currently being used, however, the ACK packet is not transmitted and the end of use of the requested channel is awaited. The ACK packet is transmitted to the sender of the synchronous packet in response to the end of use of the channel (step **214**). Processing from step **202** onward is then executed.

If it is necessary to allocate a channel to a slave station at step **202**, reference is had to the channel management table **22** to determine whether an idle channel to be allocated to the slave station exists (step **221**). If the idle channel exists, this channel is allocated to the slave station, "IN USE" is entered into the table **22** to correspond to the allocated channel in column **22***b* indicating that the channel is being used by the master station itself, and the corresponding relationship between the slave address and the allocated channel is registered in the slave management address table **23** (step **222**). Processing from step **203** onward is then executed.

If it is found at step **221** that an idle channel to be allocated to the slave station does not exist, the channel desired to be used is decided (step **223**) and the synchronous frame is transferred to the addresses of other master stations by multicasting (step **224**). Next, reception of the ACK frame is awaited (step **225**). If ACK frames are received from all master stations, the program returns to step **222** via step **201**. At step **222**, the channel decided at step **223** is allocated to the slave station, the column **22***b* of channel management table **22** is rewritten, the corresponding relationship between the slave station address and the allocated channel is registered in the slave management address table **23** (step **222**) and processing from this step onward is executed.

Thus, it is so arranged that the master stations use the notification packet to periodically notify one another of the channels used. As a result, the state of channel use can be ascertained, the same channel will no longer be allocated to

slave stations redundantly in adjacent cells and the problem of hidden terminals will not arise.

Further, in a case where all channels are in use and an idle channel to be allocated to a slave station does not exist, the master station sends the other master stations a synchronous packet which includes identification data of the channel desired to be used. When it is ascertained by a response packet sent in response to the synchronous packet that the other stations are not using the above-mentioned channel, the master station immediately allocates this channel to the slave station and communicates with the slave station. As a result, a channel desired for use can be used immediately if it is not being used by another master station. If the channel is being used, the master station can use the channel as soon as its use ends. This makes channel allocation more efficient. Accordingly, channels can be utilized more efficiently.

(d-3) Modification

In the arrangement described above, the synchronous frame is sent to all master stations and a channel is assigned to a slave station upon receiving ACK frames from all master stations. However, it is also possible to adopt an arrangement in which the synchronous packet is sent only to the master station that is using the channel desired to be allocated to a slave station and allocate this channel to the slave station when the ACK frame has been received from the master station.

Further, it is described above that the synchronous packet is sent only if there is no idle channel. However, in a case where it is desired at all costs to allocate to a slave station a channel being used by another master station, it can be arranged to send the synchronous packet and allocate the channel to the slave station.

Furthermore, in the case described above, an ACK packet is used as the response packet to answer the synchronous packet. However, the notification packet can also be used as the response packet. In such case, the periodically transmitted notification packet can be used instead of the response packet. If this arrangement is adopted, the traffic on the wired LAN can be reduced because it will be unnecessary to transmit a special response packet.

(C) Second Embodiment

(a) Configuration

FIG. **11** is a diagram showing another configuration of a wireless LAN system according to the present invention. As shown in FIG. **11**, the wireless LAN system includes master stations **11, 12, 21, 31** for wirelessly sending/receiving packets to/from slave stations, wired LANs (backbone LANS) **13***a*, **22, 32** to which the master stations are connected, cells **14, 15, 23** conforming to the master stations **11, 12, 21**, respectively, and slave stations **17, 18, 24**. Each wired LAN is laid on a ceiling and has the master stations **11, 12, 21, 31** connected to them at appropriate locations. A network repeater **41** having a bridge function is provided between the wired LANs.

The network repeater **41** has a table (a bridge path table) which stores, for every wired LAN, the addresses of slave stations under supervision and the addresses of master stations. Upon accepting a frame from a prescribed wired LAN, the network repeater **41** refers to the table and sends the frame to the wired LAN to which the slave station and master station that are the destinations of the frame belong. Further, the network repeater **41** judges that a short packet (less than 64 bytes in case of the Ethernet network), namely a packet which is shorter than the smallest packet stipulated for the wired LAN, is indicative of an error and discards this packet without sending it to other wired LANS. Furthermore, in a case where a CRC operational code is not correct, the network repeater **41** judges that an error (CRC check error) has occurred and discards the packet without sending it to other wired LANs.

(b) Description of operation

When the wireless LAN system becomes extensive, as shown in FIG. **11**, a plurality of wired LANs **13***a*, **22, 32**, . . . are provided and the wired LANs are interconnected by the network repeater **41** such as a bridge or the like. If the wired LANs differ in such a system, the problem of hidden terminals will not arise even if the same channel is allocated redundantly. This means that it will suffice merely to send the notification packet or synchronous packet to the other master stations connected to the same wired LAN. In the second embodiment, therefore, the notification packet or synchronous packet is transmitted as a short packet smaller than the minimum packet length (64 bytes) stipulated for the wired LANs.

If this arrangement is adopted, the network repeater **41** judges the short packet as being indicative of an error, discards the packet and does not send it to the other wired LANs. On the other hand, the other master stations connected to the same wired LAN do not judge the short packet as being in error, accept the notification packet or synchronous packet, which is the short packet, and execute the processing shown in FIGS. **8** through **10**.

Thus, the notification packet or synchronous packet will not be sent to another wired LAN and, hence, there will be no increase in the traffic of the other wired LAN. Moreover, since the packet has the form of the short packet, the traffic on this wired LAN to which the master station is connected can be kept low. In addition, in a case where a slave station has been connected to the wired LAN, the short packet is judged as being an abnormal packet and is discarded immediately. This makes it possible to reduce the burden upon the CPU of the slave station.

(c) Modification

The master station employs a packet of greater than 64 bytes rather than the short packet in the communication of notification and synchronous packets. Instead, the CRC operational code of the notification packet or synchronous packet is converted to a predetermined code serving as the CRC error indication.

Since the CRC operational code is not correct, the network repeater **41** judges that the notification packet or synchronous packet is erroneous, discards the packet and does not send it to other wired LANS. On the other hands, the other master stations connected to the same wired LAN do not render an error judgment in the case of the predetermined CRC operational code, even if the CRC error is indicated. These master stations accept the notification packet and synchronous packet and execute the processing shown in FIGS. **8** through **10**.

Even if this arrangement is adopted, there is no increase in the traffic on the other wired LANs because the notification packet and synchronous packet are not sent to the other wired LANs. In a case where a slave station is connected to the wireless LAN, the packet is construed to be an abnormal packet based upon the CRC error and this packet is discarded. This makes it possible to reduce the burden upon the CPU of the slave station.

Thus, in accordance with the present invention, master stations periodically notify one another of channels used by sending notification packets. As a result, the status of channel use can be ascertained and the problem of hidden terminals does not arise because the same channel is not allocated to slave stations redundantly in neighboring cells.

In a case where all channels are in use and an idle channel for allocation to a slave station does not exist, a master

station sends another master station a synchronous packet containing identification data of a channel desired to be used. If it is ascertained based upon a packet in response to the synchronous packet that the other station is not using the above-mentioned channel, the master station immediately allocates this channel to the slave station and communicates with the slave station. As a consequence, if a channel that is desired to be allocated to a slave station is not being used by another master station, the channel can be used immediately. If the channel is being used, the master station can use the channel at the end of its use. This makes channel allocation more efficient.

In accordance with the present invention, a notification packet used periodically can be substituted as a response packet sent in response to a synchronous packet. In such case the traffic on the wired LAN can be reduced because it is unnecessary to transmit a special response packet.

Further, in accordance with the present invention, the notification packet or synchronous packet is constructed in the form of a short packet the length of which is less than the minimum packet length stipulated by the wired LAN. As a result, the short packet is discarded by the network repeater and is not sent to other wired LANs. This means that there is no increase in the traffic on the other wired LANs. Moreover, since the packet has the form of the short packet, the traffic on this wired LAN to which the master station is connected can be kept low. In addition, in a case where a slave station has been connected to the wired LAN, the short packet is judged as being an abnormal packet and is discarded immediately. This makes it possible to reduce the burden upon the CPU of the slave station.

Furthermore, in accordance with the present invention, a CRC operational code of the notification packet or synchronous packet is converted to a predetermined code serving as a CRC error indication. As a result, the packet is discarded by the network repeater based upon the CRC error and the packet is not sent to the other wired LANs. In a case where a slave station has been connected to the wired LAN, the packet is judged as being an abnormal packet based upon the CRC error and the packet is discarded immediately. This makes it possible to reduce the burden upon the CPU of the slave station.

As many apparently widely different embodiments of the present invention can be made without departing from the spirit and scope thereof, it is to be understood that the invention is not limited to the specific embodiments thereof except as defined in the appended claims.

What is claimed is:

1. A master station in a wireless LAN system having a plurality of master stations each connected to a wired LAN and a plurality of slave stations each connected to a terminal for wirelessly sending and receiving signals to and from one of said plurality of master stations via a prescribed channel, each master station comprising:

a table for managing state of channel use by other master stations;

means for transmitting state of use of its own channel to other master stations periodically in the form of a notification packet;

means for receiving and storing state of channel use of said other master stations in said table when a notification packet has been received from each of said other master stations;

means for selecting a channel not being used by said other master stations upon referring to said table when communication is to be performed with a slave station under supervision; and

means for communicating with the slave station via the channel selected.

2. The master station according to claim **1**, each master station further comprising means for storing state of channel use of its own channel in said table.

3. The master station according to claim **2**, each master station further comprising:

means for sending each of said other master stations a synchronous packet containing identification data of a channel desired to be used; and

means for selecting said channel and communicating with the slave station when it is ascertained, based upon a response packet that is sent from each of said other master stations in response to said synchronous packet, that said other master stations are not using said channel.

4. The master station according to claim **3**, each master station further comprising means which, when the synchronous packet has been received, is for referring to said table to determine whether a channel specified by the channel identification data contained in said synchronous packet is being used by itself and, if said channel is not being used, for transmitting an ACK packet as said response packet.

5. The master station according to claim **3**, further comprising means which, when the synchronous packet has been received, is for transmitting said notification packet as a response to said synchronous packet.

6. A wireless LAN system having a plurality of master stations each connected to a wired LAN and a plurality of slave stations each connected to a terminal for wirelessly sending and receiving signals to and from one of said plurality of master stations via a prescribed channel, wherein each master station comprises:

a table for managing state of channel use by other master stations;

means for transmitting state of use of its own channel to other master stations periodically in the form of a notification packet;

means for receiving and storing state of channel use of said other master stations in said table when a notification packet has been received from each of said other master stations;

means for selecting a channel not being used by said other master stations upon referring to said table when communication is to be performed with a slave station under supervision; and

means for communicating with the slave station via the channel selected;

each master station referring to said table when channel allocation has been requested by the slave station under supervision, selecting a channel for communicating with said slave station and then communicating with the slave station via the channel selected.

7. The LAN system according to claim **6**, wherein each master station further comprises:

means for storing state of channel use of its own channel in said table; and

means for rewriting state of channel use of its own channel in said table when the channel is allocated to a slave station or when an allocated channel is taken out of use.

8. The LAN system according to claim **7**, wherein each master station further comprises:

means for sending each of said other master stations a synchronous packet containing identification data of a channel desired to be used; and

means for selecting said channel and communicating with the slave station when it is ascertained, based upon a response packet that is sent from each of said other master stations in response to said synchronous packet, that said other master stations are not using said channel.

9. The LAN system according to claim **8**, further comprising a network repeater connected to a plurality of wired LANs for relaying packets sent and received between wired LANs, wherein each master station transmits the notification packet and synchronous packet in the form of a short packet no larger than a minimum packet length stipulated for the wired LANs, said network repeater detects and discards the short packet, and other master station connected to the same wired LAN as said master station which transmits said packets, accepts the short packet and executes said processing.

10. The LAN system according to claim **8**, further comprising a network repeater connected to a plurality of wired LANs for relaying packets sent and received between wired LANs, wherein each master station changes a CRC operational code of the notification packet and synchronous packet to a predetermined CRC operational code and transmits the packet of the predetermined CRC operational code, the network repeater detects a CRC error and discards the packet, and other master station connected to the same wired LAN as said master station which transmits said packets, accepts the packet having the predetermined CRC operational code and executes said processing.

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